WE'LL DO IT OUR WAY: THE EARLY YEARS OF THE U.S. NAVAL TORPEDO STATION, NEWPORT, RHODE ISLAND[1]

Učinit ćemo to po svome: Rane godine američke pomorske torpedne stanice u Newportu, na Rhode Islandu

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Summary

When the U.S. Civil War ended in 1865 it became clear to the U.S. Navy that both stationary torpedoes (mines) and mobile torpedoes (spar and towed) would become important elements of naval warfare – both to deploy offensively as well as guard against defensively. Although it took four years, the U.S. Naval Torpedo Station (NTS) was set up in Newport Rhode Island to both train officers in torpedo warfare as well as develop and evaluate torpedo technology for the Navy. The fist fifteen years of the NTS (1869-1884) saw it evolve from a barren outpost with three staff to a bustling research and training center in electrical, chemical, and explosives engineering. Interestingly, the station steadfastly ignored the Whitehead Torpedo, then clearly the leading form of automobile torpedo then under development in Fiume (Rijeka). This paper will explore the origins of the NTS, the early history of its buildings as best we can discern them, describe the work carried on there in the first 15 years, and then briefly describe its later history and eventual closure and dismantling. In par-

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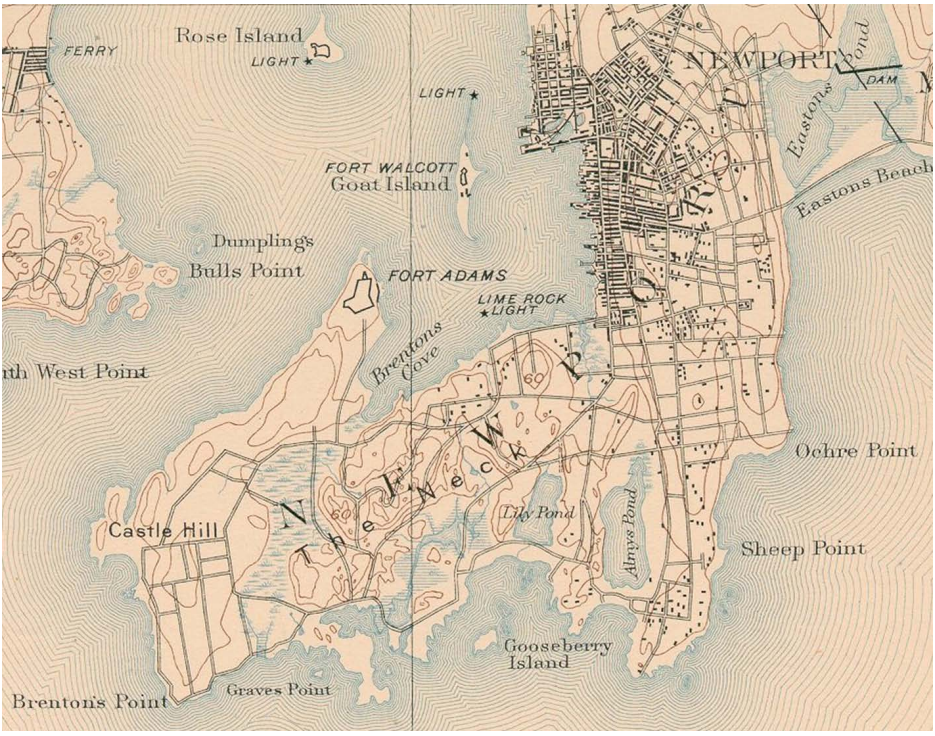
[1] The present paper is a condensation of my larger work on the NTS and its civilian personnel. This will culminate in a book on the early history of the Station entitled *Devils of Our Own: The Naval Torpedo Station in Newport, 1869-1884* and an article, "Making the Devil's Device Scientific: Walter N. Hill and the Naval Torpedo Station, 1869-1881". It has also been presented in various drafts at the Society for the History of Technology (SHOT) meeting in Minneapolis, Minnesota in 2005, and at the International Committee on the History of Technology (ICHOTEC) meeting in Leicester, UK in 2006.

ticular, it will argue that the U.S. Navy, despite good intelligence of foreign torpedo technology, charted its own, isolationist course of development and evaluation which, although impressive, ran in directions that would eventually see the United States adopting the Whitehead torpedo around the turn of the century.

With the end of the American Civil War in 1865, the United States had a great deal to contemplate. Politically, economically, and socially, the country was both tired and in many ways in ruins. The American military establishment—that is, the victorious Union military—was the largest army the country had ever had, but the Navy, too had grown with the War between the States. Technologically, the Navy had embraced ironclads during the war, but despite that forward-looking development, found itself relatively behind the Confederate States in one other area: torpedoes. Originally developed for harbor defense, stationary torpedoes nearly stopped the federal Navy from near-shore operations, but more importantly, mobile spar torpedoes struck fear in the naval commanders hearts. Spar torpedoes—explosive charges on the end of a pole rammed into a ship just below the waterline—were easy to build, straightforward to deliver (if dangerous for the attackers), and very difficult to counter. The Union struck back with its own offensive spar torpedoes, and other nations had already been grappling with this new threat in the late 1850s and early 1860s, but at the end of the War, the U.S. knew it needed to do something.

After the war, however, the country was exhausted, as was the Treasury, and Congress was slow to act. It was not until 1869 that the Bureau of Ordnance decided to set up a station for experimentation and instruction in torpedo warfare. The Chief of the Bureau, James Dahlgren, asked Captain E.O. Matthews find a suitable location for the station on the northeast Atlantic coast. Secrecy was a concern for Matthews sought a place where "experiments might be carried in free from observation." His initial choice was Oyster Bay on the northern shore of Long Island near New York. He reported back to Dahlgren that "a spot on the Eastern Extremity of Hog Island, comprising about 28 acres… fulfills all the desired conditions." The problem, however, was that the Hog Island land was owned by a pair of brothers who wanted too high an asking price for the land and that there was no public access to the mainland immediately adjacent to the island. Although the site was only twenty-eight miles from New York City and could maintain daily steamboat communication with the New York Navy Yard, Matthews cautioned that as "This branch of the profession being as yet in its infancy [it is] expected [that] series of experiments will be necessary." Carrying on these sorts of experiments "at any of our Navy Yards when vessels are constantly moving about would subject us to constant interruptions," and, he added, "To say nothing of trouble from Newspaper Correspondents." As an afterthought he briefly mentioned to Dahlgren that

■ *Map of U.S. Eastern Seaboard showing relation of Newport, Rhode Island to Boston and New York.*



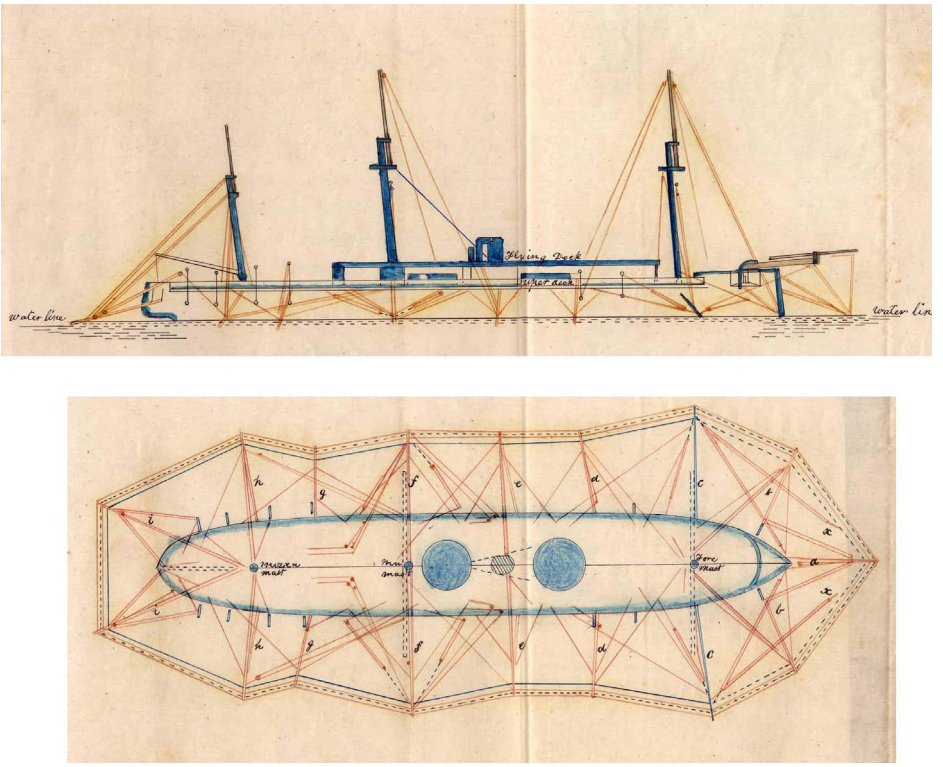
■ *Map of Newport harbor in 1894. Note that although the Torpedo Station had been on Goat Island since the early 1870s it was still only listed as having the (disused) Fort Walcott upon it.*

■ *The Naval Torpedo Station in 1876. From a display at the Naval War College Museum.*

should it not be thought advisable to purchase this place, I should recommend Goat Island in Newport Harbor. The one formerly occupied by a part of the Naval Academy. The island I believe belongs entirely to the Army and could I think be obtained by a simple request. It possess all varieties of water and experiments could be conducted very quietly there.[2]

Newport, Rhode Island sits near the mouth of the twenty mile long Narragansett Bay, her harbor protected from the Atlantic by a cape. (Figure **1**) At the tip of that cape sat Fort Adams, a massive Third System fort rebuilt in the 1820s, which oversaw the entrance to the harbor and protected it from any unwanted entry. Fort Adams hade replaced the then disused Fort Wolcott (formerly Fort Anne and then Fort Washington) on Goat Island, a small barrier island in Newport's inner harbor. (Figure **2**) During the Civil War, the U.S. Naval Academy had been relocated from Annapolis to Newport, as Maryland had been too close to the Confederacy for the Navy's comfort, and many naval officers saw Newport as a second home. With strong naval ties, good communications, a fortified harbor, and good rail connections with both Providence and Boston (both cities would provide materiel and technicians for the Torpedo Station), but also slightly away from prying newspapermen's eyes, Newport offered the ideal nurturing ground for a new arm of the U.S. Navy. Chief Dahlgren decided to forego trying to purchase the land on Hog Island, negotiated the cost-free transfer of Goat Island from the Army to the Navy, and promptly sent Matthews to Newport to begin building the U.S. Naval Torpedo Station [NTS]. (Figure **3**) The Navy became immensely proud of the torpedo work at Newport, for at the Centennial Exhibition of 1876 (the one where Thomas and Edison and Alexander Graham Bell first publicly displayed their electric light and the telephone), the Navy Exhibit *was* the products of the NTS. By 1881, the Station's presence within the Navy was such that when the Navy decided to send a delegation to the 1881 International Exposition of Electricity

[2] Matthews to Dahlgren, 25 June 1869 [National Archives and Record Administration (NARA), RG 74, Letters Received from Navy Yards and Stations, vol. 1, 1864-1870 , p. 3—copy in the Naval War College (NWC), Newport, RI vertical file]



■ *Proposal from c1871 for anti-torpedo netting. From the Torpedo Station manuscript collection, Naval War College, Newport, RI.*

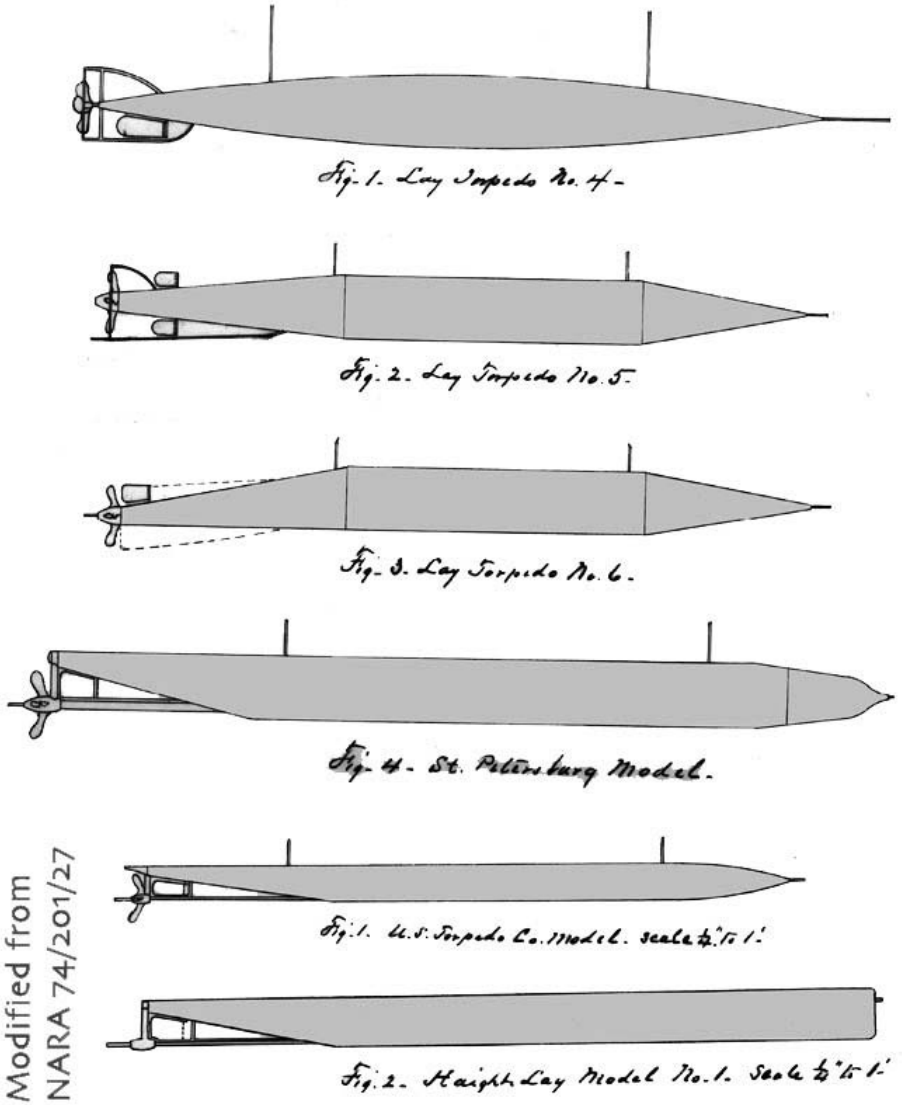
in Paris, the Station was contacted with a carte blanche of what they might want to display, while other departments were told what they should send.[3]

INITIAL STUDIES

While the U.S. Navy decided to go it alone, they were not working blindly. Robert Whitehead's work in Rijeka had begun in 1864 and the NTS was aware of Whitehead's ideas from their inception. The U.S. Attaché in Trieste had forwarded reports of Whitehead's trials in 1868 to the Secretary of the Navy, and the Navy had immediately handed them to E.O. Matthews, the commander at the NTS at its very inception. Matthews kept the reports for just over a month, and then returned them to the Chief of the Bureau of Ordnance, but retained the drawings in order to make copies for the NTS's work.[4] In 1869 the

[3] Jeffers to Selfridge, 6 April 1881 [letterbook 1878-83 (hereafter 'LB78-83'), p. 184 in the Naval Torpedo Station collection, Naval War College (hereafter 'NWC'), Newport, RI, box 365].

[4] Matthews to Case, 16 Nov. 1869 [NARA RG 74/19, Letters Received from Navy Yards and Stations box 163, vol. "Torpedo Book", no. 30].



■ *A small selection of various torpedoes experimented on at the NTS in the 1870s, from a manuscript of station researches to 1876. Compiled from National Archives and Record Administration [NARA], Washington, DC, Records of the Bureau of Ordnance, RG74/201/27.*

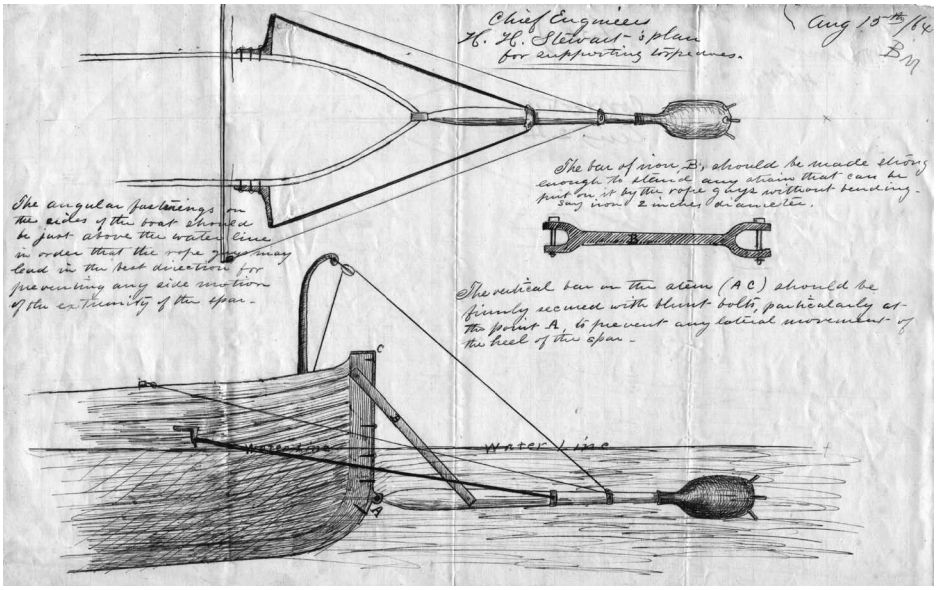
USS *Franklin* had been sent to Fiume to observe trials of the Whitehead. The U.S., in the sort of arrogant self-sufficiency that besets many militaries, declined to purchase, or even test Whitehead style torpedoes until the later 1880s (although a Brooklyn company had them under license from the mid-1870s), and finally admitted defeat and adopted them in 1892.

■ *Two of the original Torpedo Station torpedoes on display in the museum of the Naval War College. On the left is the station "fish" torpedo and on the right is an early-model Howell torpedo.*

Various Navy captains and lieutenants also proposed ideas and the Station often functioned as a testing house for a smorgasbord of inventions submitted to the Bureau of Ordnance (BuOrd). In the first 2-3 years of its existence the station also entertained ideas for such things as anti-torpedo netting (Figure **4**), as well as an electrically detonated hand grenade deployed from what looks for all the world like Batman's utility belt, although these "diverse" proposals seem to have been weeded out by the BuOrd by about 1872 and they concentrated on torpedoes proper. In the first 5-8 years, some naval officers with a keen inventive spirit as well as some ability were briefly stationed at or frequently rotated through the NTS in training courses. Here is a perfect case study in the sort of science these officers were taught at the Academy in Annapolis and the sort of engineering the new field of torpedo warfare demanded.

In the first years of the station, work was ongoing with spar torpedoes, towing torpedoes, as well as with self-propelled or "automobile" torpedoes. Class assignments seems to have been based on how to develop an effective automobile, or "fish", torpedo. (Figure **5**) The station developed its own fish torpedo (Figure **6**) as well as experimented with multiple models of at least three other types of torpedoes.

If we look for a moment at the proposal by Lieut. Samuel Very, we can see how scientific mentalities were creeping into the Navy already, but also how scientific misunderstanding (or mis-optimisms) tended to overshadow the plans. Lieut. Very's torpedo was a symmetrical cigar-shaped craft, with two fixed, horizontal fins athwartships for resistance to vertical movement. The largest potion of his proposal is spent working out the volume of rotation of a chord about the central axis—a sort of applied conic sections derived from Haswell's *Engineers' and Mechanics' Pocket-Book*—suggests that Very and other naval officers approached torpedo design mathematically, although perhaps not very practically. Very's described the motive power for his fish torpedo: "an engine contrived to operate [three] paddles projecting from the stern of the torpedo… to propel the case by a kicking motion, similar to that produced by the feet in swimming." The outer two would work in unison with the central one 180˚ out of phase, keeping "a propelling power constantly operating on the water to advance the torpedo." The paddles should have a parabolic shape in order to counteract "the effect of the loss from what is called in a screw propeller the centrifugal motion." There is clearly some appeal to scientific principles, although perhaps a Heath Robinson design in the end.



■ *Chief Engineer H.H. Stewart's plan for spar torpedoes, 15 Aug 1864. Stewart's method was not ultimately adopted, and the typical method of attachment became a long side-mounted pole (rather like jousting), though the concept remained the same: attempt to close and detonate a gunpowder charge into an enemy hull below the waterline. From National Archives and Record Administration, Washington, DC, Naval Records Collection of the Office of Naval Records and Library, Still Pictures (NWCS-S), RG 45/BM/box 150.*

Further, Very proposed the ammonia engine based upon an interesting observation that ammonia is readily absorbed by water. He therefore surmised that after it powered the engine, on a piston he presumed, then it would be exhausted into a chamber containing some water (possibly the depth bladder?), be absorbed, and thereby create a partial vacuum, increasing the pressure gradient between the high- and low-pressure ammonia reservoirs and hence increasing the engine's efficiency. Although this would not in fact work, and in a similar manner his arguments about the desirability of a gyroscopic stabilizer are misguided, Very clearly relied on a chemical and physical education from the Naval Academy and tried to apply it in the sprit of the age.

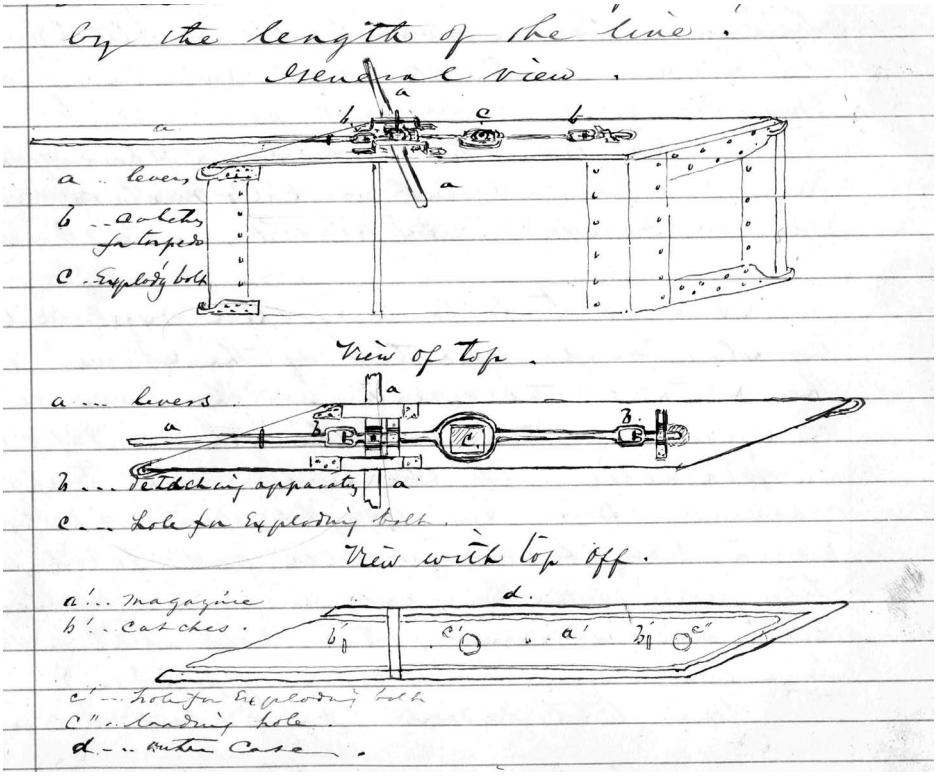
Where the officers did excel was in bringing back sending back reports and sketches as they saw other countries' torpedoes deployed around the world in foreign ports during the 1870s.[5] Lieut. Very aside, there were some notable standouts: Lieutenants R.B. Bradford and Frank M. Barber, in particular, developed numerous torpedoes, firing devices, and fuse arrangements—they, too, corresponded frequently with Station personnel, even when stationed abroad—and they subsequently became the American authorities on Torpedoes.

RUNNING A STATION

With respect to organization, there were four departments at the Station: Torpedo construction, Torpedo tactics, Fuzes and Explosives, and Electrics. The administration of the departments shows the divide under investigation here quite nicely: the first two were headed by naval officers (with civilian machinists doing the construction), while the latter two were run by civilians, Walter N. Hill and Moses G. Farmer, respectively. In the first decade of its existence, the Station undertook research on the technologies of torpedo attack and defense, produced significant portions of torpedoes for the Navy at the time, and also instructed classes of sailors in torpedo tactics. In these classes some theory was provided, but the emphasis was on hands on understanding of types of fuses, explosives, equipment, and how to operate them.[6] A very brief survey of the

[5] See NWC, box 366, LB "Automatic Movable Torpedoes": Lt. Cmdr. C. F. Goodrich (trans), "Description of the Whitehead Torpedo," [1879?] (pp. 231-162) and "Sketch of a Whitehead Torpedo Carriage in use on board the English Ironclad Fleet, Sea of Marmora," 20 Aug 1879 (p. 135)

[6] So for example, in the fourth class meeting, students were instructed in the composition of F_1 Fuzes. These were made of "Red Phophorous [P], Antimonious Sulphide [St_2S_3], Graphite [C] and Potassium Chlorate [$KclO_3$]," and then given the percentage compositions of each, but the emphasis was on knowing how many grams of each was needed to make up a batch for a dozen fuze plugs. Clearly the students were expected to have an elementary grasp of chemistry and chemical notation, but manufacture and use was the primary goal, as he longer list of 'ingredients' included "One hollow plug, One flat point screw, One sharp point screw, Two copper wires (no. 20) 6" long, Solder, E4 composition, Collodion, Glue, One paper 3" by 8", Powder, Twine, and Shelac." In the colder months, for at least half of the course of instruction each man in the class spent many days manufacturing their



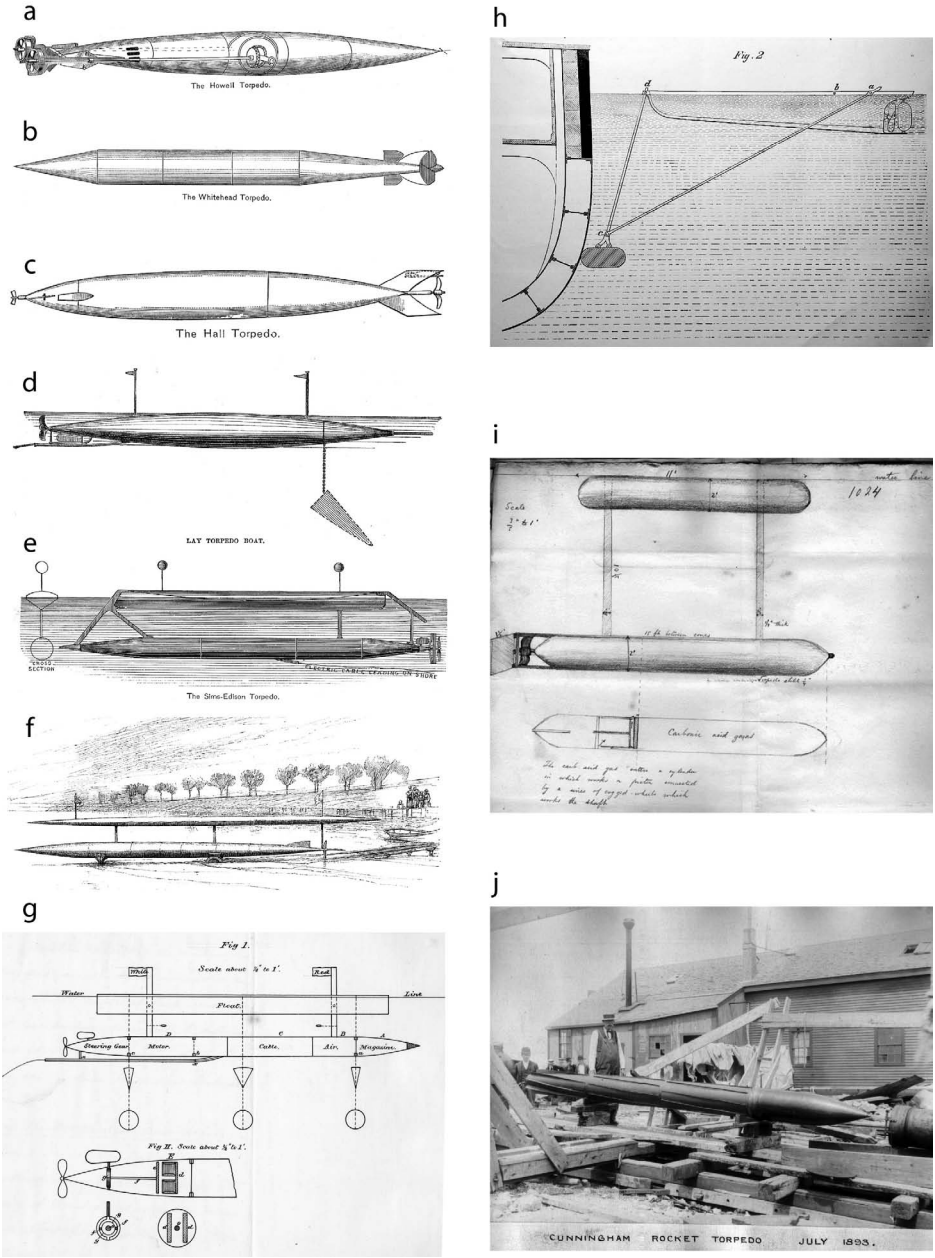
■ *Experiments with towing torpedoes, Naval Torpedo Station, c1573.*

tasks attempted at the Station in its first 15 years will serve as a background to the more interesting story of the two civilian scientists at the Station.

When Lieutenant William B. Cushing attacked and sunk the ironclad CSS *Albermarle* with a spar torpedo at the end of the Civil War, these curious devices became standard equipment for the Union. The Navy enthusiastically adopted the concept of an explosive shell tied to the end of a long pole, or 'spar', and shipped overboard some 20-30 feet ahead of the boat and 5-10 feet below water. (Figure 7) When the launch ran against an enemy and exploded the torpedo, the target stood little change of surviving.

That was in theory, of course. In reality, spar torpedoes were finicky, temperamental, and difficult to maneuver, never mind that closing on an enemy ship at a top speed of less than 5 knots under enemy fire was risky to begin with. Nevertheless, immediately after the Civil War, the Navy began issuing spar torpedoes to its steam launches, and it fell to the Station immediately after

own fuses that could then be used by their own or other classes the warmer days—and possibly for service aboard all naval ships.



■ *Various torpedoes tested at the Naval Torpedo Station in the 1870s and 80s.* **a**-**f***) compiled from G. Herreshoff, "The U.S. Naval Torpedo Station," The New England Magazine n.s. 26 (1902): 167-181, Lt. W. S. Hughes, "Modern Aggressive Torpedoes," Scribner's Monthly (April 1887): 427-37, and Allan D. Brown, "Torpedoes and Torpedo Boats," Harper's New Monthly Magazine 65.385 (June 1882): 36-47;* **g***) Simm's Electric torpedo from Naval Torpedo Station collection, Naval War College, Newport, RI [NTSc-NWC];* **h***) underwater spar torpedo from Capt. John Ericsson, Movable Torpedoes, copy in National Archives, Kew, ADM 1/6283, ;* **i***) Walter Hill's carbonic acid torpedo from Hills' notebook, NTSc-NWC;* **j***) Cunningham's rocket torpedo, NTSc-NWC*

its inception to develop more effective and reliable torpedoes and ignition systems. From January 1870, Station personnel worked in parallel on the torpedo cases, firing fuses, ignition systems, and fittings for the launches. It is unclear from the records who was assigned to which task, although it is a reasonable guess that the Station chemist, Walter Hill, was in charge of testing various chemical compositions for fuses, and the Station electrician, Moses Farmer, worked on electrical detonators.

While the most commonly understood form of "torpedo" was a floating explosive device in the water, it took little imagination after the Civil War to make the floating mine mobile by towing it behind a boat. (Figure **8**) A towing harness on the boat made the torpedo tow to one side like a water-skier, so that it could strike the enemy vessel below the waterline, rupturing its hull and sinking it. Experiments on towing torpedoes began even before the official establishment of the Station and belie the *ad hoc* nature of this work.[7] E.O. Matthews, soon to be the first commanding officer of the Station made a trial while still at Annapolis in May 1869. He outfitted a galvanized iron float which held a horizontal bar, holding the torpedo out in front of the float and about ten feet below the water. Although in towing trials, Matthews could get a divergence of the torpedo 30˚ to 35˚, the whole rig was considered unwieldy and cumbersome and was abandoned, although various forms of a model known as the Harvey Towing Torpedo were continually tested at the Station through the mid-1870s.

In the first 15 years of the NTS's existence, Station personnel worked on numerous other designs. (Figure **9**) There was the Simms Electric torpedo with trailing wires for guidance and detonation (This torpedo is often referred to the Simms-Edison torpedo, as Thomas Edison partnered with the patentee, Winifred Simms, to bring the torpedo to market). The Weeks Rocket torpedo worked well, until it overshot, ran up on land, and destroyed a local house. Initially the Station personnel and the Navy seemed to favor the mammoth Lay-Haight model, steered by electrical wire and detonated remotely. The Howell Gyroscopic Torpedo, which used a 330lb. flywheel spun up to 10,000RPM to drive and steer the torpedo, was a favorite for a number of years—the Howell in fact was the mainstay of the U.S. Navy until 1898, when they finally gave in an licensed Whitehead-style torpedoes.[8] In all, during the Station's first fifteen years, no less than 8 known types of towing and automobile torpedoes were built and/or tested at Newport.[9]

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[7] Unless otherwise noted, information on towing torpedo experiments comes from NWC, box 383, ledger 10, "Towing Torpedoes". Although the ledger contains references to letter-keyed figures, these were apparently in another as yet unidentified book and therefore have been silently omitted in any direct quotes.

[8] The announcement was made in 1890, to the surprise of many naval analysts; see "The Whitehead Torpedoes," *New York Times*, 11 September 1890, p. 4.

[9] They investigated Stibb's Submarine Movable Torpedo, Knapp's Automatic Torpedo, Howell's torpedo (at length), Pillsbury's device for a Submarine Torpedo, Asa Weeks

The Station did try to make a Whitehead-style torpedo, generally known as the Station "Fish", and although the actual machine survives in the Naval War College Museum in Newport (Figure **6**), little documentation on how it worked, or more importantly, how it failed to work, remains. The surviving sleek, fifteen-foot brass Fish mirrors proposals by a number of naval officers for a torpedo with a 150lb. gunpowder warhead propelled by compressed ammonia gas, although guncotton for the warhead and carbonic acid gas (compressed CO_2) as fuel were also tried. Whether this one has the proposed vertical gyroscopic stabilizer (like the Howell) is unknown, as current UXO regulations do not allow its case to be opened.

"THE PROFESSORS": WALTER N. HILL AND MOSES FARMER

Walter Nickerson Hill came to the Station at its inception, having been recommended by some of the most important scientists of the day, and also likely through the influence of his soon-to-be father-in-law, Augustus L. Smith, then a professor of mathematics at the Naval Academy. Hill appears to have been an exceptionally good student at the Lawrence Scientific School (later incorporated into Harvard University), graduating second in his class at Lawrence under Oliver Gibbs. While at the NTS, he continued to remain active in academic matters—and was always referred to as 'Professor'—and published a number of scientific papers. His work on carbonic acid gas came directly out of researches at the station, and another paper on electromagnetic induction heating effects co-authored with James Trowbridge, then a Harvard professor himself and who had graduated with Hill in 1865 (along with the poet Longfellow, by the way), was cited into the twentieth century as seminal in its field.[10] Hill worked on numerous projects, but primarily became an expert on explosives, penning articles for the popular and scientific press, and by 1881 moved into the relatively new field of nitroglycerine manufacture.[11] He was even called as an expert witness by the DuPont company for a mining accident case in Montreal in the winter of 1880.

By comparison, the position of Station electrician was given to Moses G. Farmer who patented the first successful telegraphic fire alarm, and whose shop in Astoria, Connecticut likely gave Thomas Edison the idea for the incandescent light bulb. As early as 1854, Farmer had lit his house on Pearl Street in Salem,

rocket torpedo and some small attempt was made to see what others were doing with Whitehead torpedoes, although it does not appear that any of these were tested at the Station itself. For these, see the ledger on "Automatic Movable Torpedoes," 1869-79 [NWC, box 366] and for Weeks, see LB78-83, pp. 132c-128 [NWC, box 365]

[10] See Trowbridge and Hill papers, Brown University Library, Providence, RI.

[11] Jeffers to Selfridge, 14 March 1881 [LB78-83, p. 179, NWC, box 365]—Selfridge (thought HILL?) had submitted the proposal only 2 days before.

■ *Lay-Haight torpedo on the wharf at the Naval Torpedo Station, late 1870s. From E.W. Jolie, "A Brief History of U.S. Navy Torpedo Development," Naval Underwater Systems Center, Technical Document 5436, 15 September 1978 , fig. 8. Online at <http://www.hnsa.org/doc/jolie/part1.htm>.*

Massachusetts with electric lights. Brought to the station in 1874—although though what connections, under what circumstances, or at what rate of pay is a complete mystery—Farmer spent the next 7 years in Newport developing various wet-cell batteries and electrostatic generating machines for use by the Navy. Farmer's time at the Station is remarkably under-documented, but the Navy must have been looking for one of the nation's top electrical inventors when they enticed Farmer to Newport.

Professors Farmer and Hill seem to have had some freedom to experiment with what took their fancy, as in 1878, when they hooked up two telephones in their houses, some 250 feet apart, but not connected by wires to each other. Rather, they hooked one wire to the common gas pipes and the other to the water pipes which were independent in each house. Farmer noted in an official report (incidentally, defending himself against charges of having done nothing of value to the Station) that, "Conversation was carried on by means of the two instruments without difficulty." They also tried connecting a telephones receiver to the existing telegraph system that connected the officers' houses to the electrical laboratory and discovered that through them they could hear the station launch's bell ringing (an electrically activated bell) because the telegraph system and the electrical leads to the bell ran together in a common trench, thereby noting a sort of circuit cross-talk induction effect.[12]

Beyond the individuals, however, the Navy itself set the research program at the station, and the story of the Lay Torpedo at the Station demonstrates exactly how the Navy could have embraced and yet misused the science and scientists at its disposal. In August of 1872, John Lay, an inventor from Buffalo, NY,

[12] Farmer to Ramsay, October 1878 [Misc. files, p. 66-64, NWC, box 361].

entered a contract with the Bureau of Ordnance for $12,000 upon the successful delivery of a submersible boat with explosives and electrical remote steering, or, as it subsequently came to be know, the Lay torpedo.[13] (Figure **10**) His method was a novel one, using compressed carbonic gas in pressure tanks to both drive the propeller and also compressed gas in adjacent tanks to steer the torpedo. Lay delivered a prototype to the Station in 1874 and for the next 18 months, the Station put it through a series of tests, and in particular attempting to manufacture and test the high-pressure flasks.

When the Navy entered into the contract with Lay they assigned the station chemist, Walter Hill, the task of understanding and improving the flasks, valves, and carbonic acid gas development. The station had John Matthews of New York City fabricate the gas flasks, based on his fabrication of steel cylinders for trendy soda water fountains of the day. The torpedo cylinders, however, were pushing fabrication abilities for the day. Hill discovered that the size pressure flasks the Station had wanted could not be made because rolled sheet steel was not commercially available in large enough sizes. He recalculated a series of smaller flasks that could be fabricated to accomplish the task: coiled cylinders made sheet steel for multi-layer strength. While Hill calculated that these flasks could bear 5,000psi (the main cylinders only needed to take 900psi), given the state of stress theory in the 1870s, he still recommended that an extra one be ordered and be tested hydraulically to failure.[14]

Although his idea was sound, it turned out that now *long* enough sheet steel was not available, so they came up with a scheme of nested, welded cylinders with staggered seams, all then made a solid mass by melting in a lead-tin solder. While this clearly required more complex manufacturing as well as considerable experimentation "to get the practical details right [in this] work of a new and unusual character," as Hill put it, they seem to have pulled it off, for in late November 1874 the cylinders were delivered to the Station—although not before one more emergency trip by Hill to New York to solve problems with the design of the four-layer cylinder end caps.[15]

In effect, in experimenting with the Lay Torpedo, the Naval Torpedo Station was doing cutting edge pressure research. Typical high pressure steam engines of the day worked at about 800-1000psi (and maximum trial pressures of

[13] Contracts between the Navy and Lay are found in "Lay Torpedo" ledger [hereafter 'NWC 361 (Lay)'], pp. 4-1 (7 Aug. 1872) and modified with more detailed and ambitious criteria for $15,000 at pp. 55-53 (20 July 1875) [NWC, box 361]. The majority of detailed information on the production of the Lay torpedo is in this volume.

[14] Hill to Simpson, 10 July 1874 [NWC 361 (Lay), pp. 14-9].

[15] Hill to Simpson, 17 July 1874 and 30 Sept. 1874 [NWC 361 (Lay), pp. 16-15 and 24-17]. Although Hill had some hydraulic theory to calculate pressures, at this time, pragmatic design still ruled, for when they tested some end caps with a moderately square cross-section and they bulged out initial plastic failure at only 2500-2600psi.

2000psi were virtually unheard of), while compressed gas or gas tanks for things like welding or fuels were as yet decades away. Even though he had experience in manufacturing pressure flasks, Matthew's shop in New York for example, did not have a hydraulic pump that could even reach 1000psi, and in order to get even 400psi there, Hill had to fill a tank with water add some carbonic gas, and then heat the whole tank in a hot water bath, itself causing all sorts of expansion issues as well.[16]

Beyond the tanks, Hill also advanced the state of the art for carbonic acid gas generating motors (which also eventually became his first U.S. patent).[17] Citing researches of Michael Faraday and Henri Victor Regnault (1810-78), as well as his own paper in the Navy's Bureau of Ordnance publication series printed at the Torpedo Station, Hill argued that his work developing new apparatus that could test carbonic acid in the much larger quantities, and under rather different conditions than these noted scientists had done, was imperative for developing the Lay torpedo.[18]

In addition, the Lay torpedo was steered by means of electricity—the switching of which also occupied Hill's (and perhaps Moses Farmer's) time—and Lay himself claimed that in order to make his whole system work, he needed ten months to construct a sufficiently strong dynamo, or the Station could allow him to use their newly purchased Farmer's dynamo—a request that William N. Jeffers, the relatively new head of the Bureau of Ordnance, quite rapidly assented to. Unfortunately, after shipping Farmer's dynamo to Buffalo and even in consultation with Prof. Farmer himself, Lay discovered that the machine would not suit the purposes without "causing it to revolve at such rate of velocity as to impair its construction." Clearly the NTS was engineering beyond the state of the art for 1874.

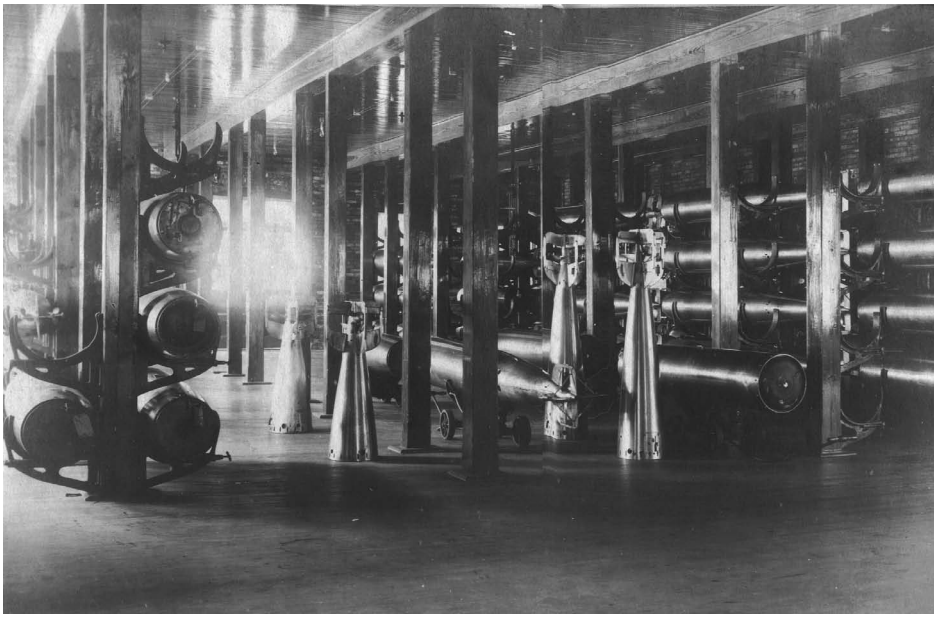
The Naval Torpedo Station in Rhode Island functioned partially like Thomas Edison's Naval Consulting Board would during WWI, where inventions by both civilians and other naval officers and engineers would be submitted either to the Station directly, or to the Board of Ordnance and then forwarded on for evaluation. As their projects expanded, so did the station. By the mid-1870s, they had a machine shop, an explosives lab, electrical shop and its own power plant. (Figure **11**) As really the only station dealing with the then advanced electrical and chemical technologies of the day, the NTS received a great number of external evaluation projects.[19] Searchlights, dynamos, switches, and

[16] Hill to Breese, 9 Feb. 1876 [NWC 361 (Lay), pp.102-99].

17 Hill to Simpson, 27 June 1874 [NWC 361 (Lay), pp. 8-4]. U.S. Patent no. 163, 376, "Improvements in Machines for Making Liquid Carbonic Acid."

[18] Hill to Simpson, 8 May 1875 [NWC 361 (Lay), pp. 42-35]. Walter N. Hill, manuscript paper on file at NWC.

[19] Two very large pressbooks of something over a thousand suggestions to the BuOrd on torpedo warfare survive in "BuOrd Suggestions 1871-1873" [NWC, box 367] and in a led-



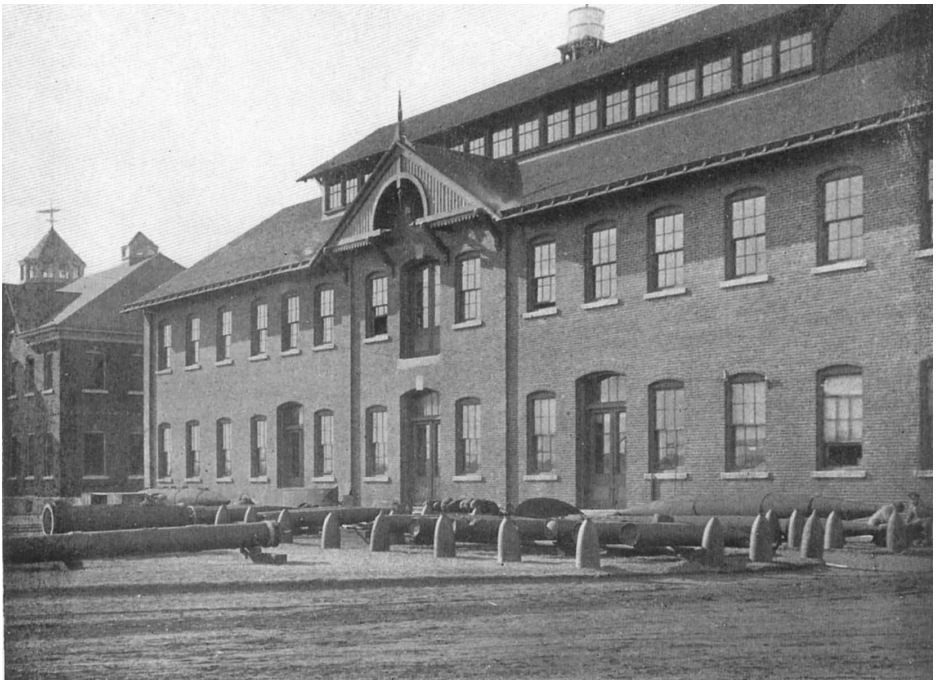
■ *Naval Torpedo Station store rooms, perhaps in the 1880s. From NARA, RG 74/B/53F/1.*

lighting systems all came out of the Station, and batteries seem to have been of particular interest. As early as 1873 the Fuze Dept. was experimenting with dry cells; Le Clanché batteries had been installed on naval ships since as early as 1874; the installation and repair of most electrical equipment on navy ships also fell to the Station.[20] Dynamos, too, were being tied to the steam engines of the

ger labeled "Suggestions" for 1874-81 [NWC, box 361]. The range of contents there includes some quite serious naval engineers and ship's masters offering improvements in torpedo launching (from a deck-mounted Dahlgren gun, for example) to more complicated schemes for constant depth torpedoes to quite detailed calculations (*without* using modern calculus) on the buoyancy or drag of fish torpedoes (quoting acknowledged experts like the physicist, William Rankine). Many of the officers who went through the NTS or were stationed there have suggestions represented. The suggestions all do seem, however, to be feasible, or at least there are none of the class which Edison received in WWI (such as defeating submarines by "charging the sea with electricity"), so it would see that the Bureau or the station commander did some initial winnowing of which to save and which to dispose of. For Edison and the Naval Consulting Board suggestions, see Daniel Kevles, *The Physicists* (Cambridge: Harvard University Press, 1987) and William M. McBride, "The "Greatest Patron of Science"?: The Navy-Academic Alliance and U.S. Naval Research, 1896-1923," *Journal of Military History* 56.1 (1992): 7-34.

20 "Record of… Experiments in the Fuze Department," 11 March 1873, p. 22 [NWC, box 361]. "Le Clanché-Ruhmkorff [cells]… obtainable in Paris" seem to have been Bradford's initial favorites, although "Chlorine Batteries" and "Pneumatic Batteries" were also tested but seem to have failed various tests; R.B. Bradford to K.R. Breese, 3 Aug. 1875 ["Electrical Batteries and Machines" ledger, p. 24 *et seq.* (NWC, box 363)]. Farmer's type dynamos, however, remained the standard, although Bradford argued that "all human agency in the way of crank turning, should be done away with, as much as possible."

■ *The Naval Torpedo Station, electrical laboratory c.1902. From Grace Herreshoff, "The U.S. Naval Torpedo Station," New England Magazine 26.2 (1902), p. 169.*



■ *The Naval Torpedo Station, machine shop c.1902. From Herreshoff, p. 178.*

newer ships, and these also offered *numerous* troubleshooting possibilities for Station personnel, in addition to their work on the evaluation and development of all the various automobile torpedoes in the 1870s.

TRANSITION

By the early 1880s, however, the NTS was about to enter some rough seas. With the phenomenal growth of the role of torpedoes in naval warfare, and the arming of all naval fleets with some type of torpedo, the U.S. Navy began sending more and more naval officers and junior officers through the torpedo school. At the same time, it became clear to the admirals that the Navy also needed a post-graduate strategy school to effectively engage in deep-water, iron-hulled naval warfare. New technologies demanded new strategies, it seemed, and the Navy decided that the man to lead them in this endeavor was Alfred T. Mahan. Mahan, best known for his seminal *The Influence of Sea Power Upon History* (1890), became an early president of the U.S. Naval War College, opened on a neighboring island in Newport in the fall of 1884. At the same time, the Naval Training School which had been in Newport for a few years took over part of the Goat Island and briefly administratively absorbed the Naval Torpedo Station as well. The difficulty came from a conflict over the Navy's vision of what the NTS was to be. Was it to be a training facility, or would it be a research facility? In the first case, merging with the War College and the Training Station would make sense, while in the second, merging made little sense at all.

There was a third option seriously considered for a time by the Navy: the NTS could become solely a production center for U.S. torpedoes themselves. The Station had used its trainees for many years to assemble fuses for spar and other torpedoes as they were learning the principles of the explosives. Whether the demand for fuses outstripped the ability of the number of officers going through the program to make them, or the officers or the admirals felt that this was no longer appropriate work for the officers, by the turn of the century the NTS housed numerous workshops and a new administration building was completed in 1902 to coordinate a predominantly civilian workforce building torpedoes for the Navy. (Figures **12** and **13**)

The Navy had always bought torpedoes from private manufacturers, and in 1890 they finally bought the rights to manufacture Whitehead torpedoes in America. Two years later they finally contracted the American Torpedo Company for Whitehead torpedoes. The NTS would, however, remain the main governmental U.S. torpedo factory until just after World War I when a major new factory was opened in Alexandria, Virginia, and with others at Mare Island, California (in San Francisco Bay) and later an undersea warfare station in Keyport, Washington would lead the U.S. Navy into the twentieth century.

This however, goes beyond the scope of the story at hand. The Newport Naval Torpedo Station's first decade and a half saw it evolve from a small collegial installation run by passionate individuals, into a large-throughput training facility for the line officers of the Navy during a transition to the all steel Navy. By the time Teddy Roosevelt inaugurated the American blue-water Navy in the last years of the nineteenth century, the Naval Torpedo Station was celebrating its 25th anniversary as a key link in developing the torpedo capabilities for that Navy.

Sažetak

Kada je 1865. završio Američki građanski rat, američkoj je mornarici postalo jasno da će i stacionarna i pokretna torpeda postati važnim elementima pomorskog ratovanja – i za napad i za obranu. Iako je trebalo četiri godine, američka je pomorska torpedna stanica postavljena u Newportu na Rhode Islandu da bi obučavala časnike ratovanju torpedom, ali i da bi razvijala i ocjenjivala tehnologiju torpeda za mornaricu. U prvih se petnaest godina (1869.–1884.) stanica razvila iz oskudnoga vojnog kampa s tri stožera do zaposlenog centra za istraživanje i obuku u inženjerstvu za elektriku, kemiju i eksplozive. Zanimljivo je da je stanica uporno ignorirala Whiteheadov torpedo, a onda i vodeći oblik automobilskog torpeda koji se tada radio u Rijeci.

Ovaj će rad prikazati početke pomorske torpedne stanice i ranu povijest njezinih zgrada na način na koji ih najbolje možemo razabrati, opisati koji su se radovi u njoj izvodili u prvih petnaest godina i zatim ukratko opisati njezinu kasniju povijest i konačno zatvaranje i ogoljenje. Posebno ću zastupati tezu da je američka mornarica, usprkos oštroumlju stranih torpednih tehnologija, slijedila svoj vlastiti odvojeni put razvoja i procjene koji je, iako impresivan, ipak išao smjerovima koji su naposljetku na prijelazu stoljeća prihvatili Whiteheadov torpedo.